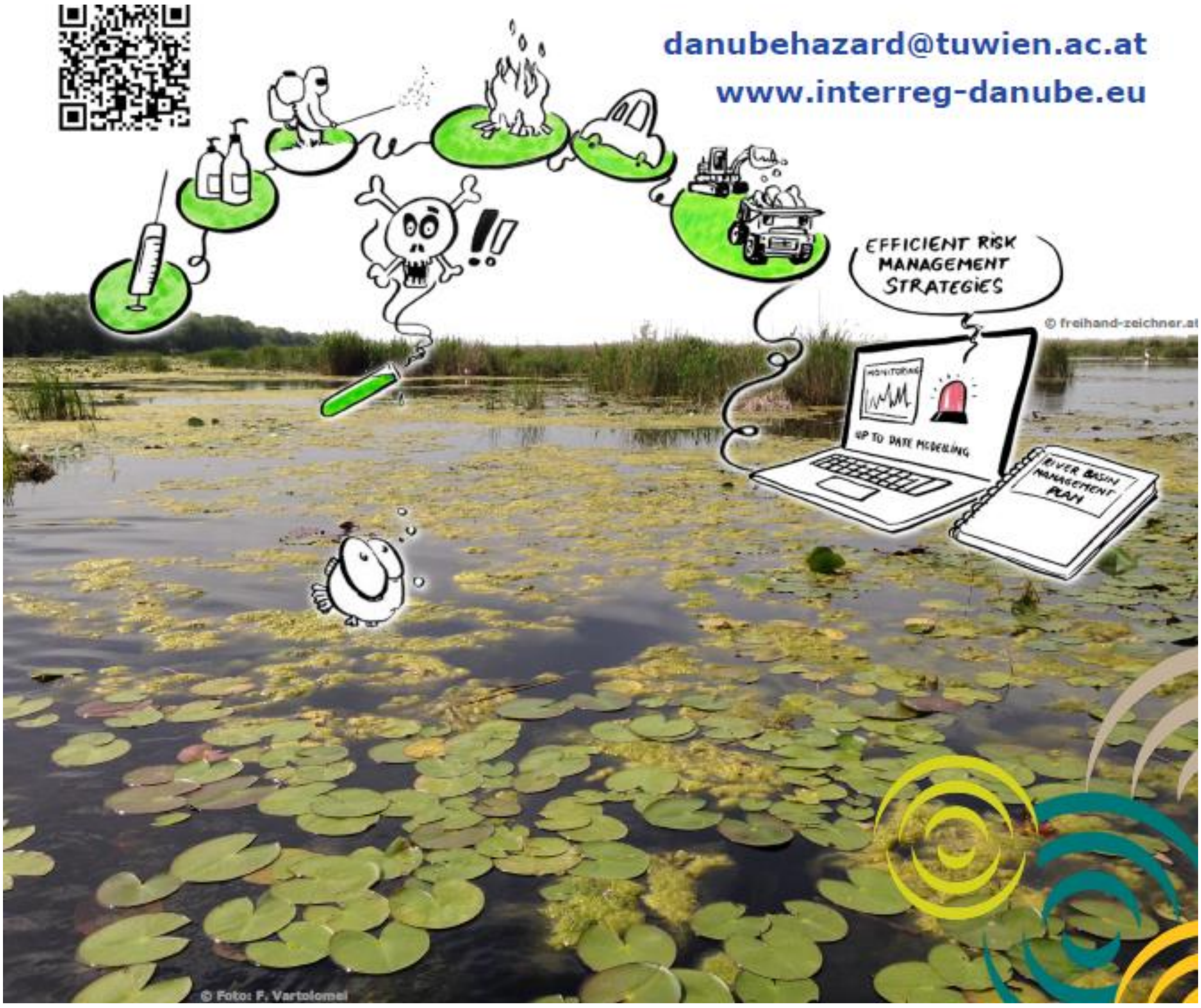

Output T2.3

Demonstration of the management plan development process at watershed levels for Hazardous Substances pollution based on detailed emission modelling in seven pilot regions 2023

Factsheet for the Wulka pilot region

Project co-funded by European Union funds (ERDF, IPA, ENI) and National Funds of the participating countries

PROJECT TITLE: Tackling hazardous substances pollution in the Danube River Basin by Measuring, Modelling-based Management and Capacity building

ACRONYM: Danube Hazard m³c

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1. Introduction

Amongst other tasks, Danube Hazard m^{3}c was carried out to fill knowledge gaps in the management of hazardous substances in the Danube Region and to demonstrate modeling as a support system for the EU-WFD Management Cycle. In seven pilot regions in Romania, Bulgaria, Hungary and Austria, detailed monitoring strategies were established to close data gaps in several technical and environmental compartments. Emission modelling, using the MoRE Model was established, based on intensive data acquisition, which was carried out by the responsible project partners of pilot regions and supported by the Environment Agency Austria.

After validation of the model for several chemicals from different substance groups (e.g. industrial chemicals: PFOS, PFOA; heavy metals: Cd, Cu, Cr, (…); pharmaceuticals (Diclofenac, Carbamazepine) and for the first time pesticides (Metolachlor, Tebuconazole), results were used to demonstrate:

- The use of Emission modelling to support the risk analyses
- The use of Emission modelling to characterize regional sources and pathways (system analyses)
- The use of Emission modelling as support system for establishing a Program of Measures
- The use of Emission modelling to quantify the effectiveness of mitigation measures by scenario-analyses.

The pilot regions were selected in advance to reflect various stress situations and focal points, such as rather undisturbed regions like Ybbs or Vit, regions significantly influenced by a large Waste Water Treatment Plant (WWTP) like Somesul Mic, regions with increased anthropogenic activities (Wulka, Zagyva), a region with significant agricultural use (Koppany) and a region, influenced by abandoned mining (Viseu). Each pilot region shows characteristic patterns of stresses from Hazardous Substances. The identification of these stresses and the way to manage them, supported by model results should be briefly summarized in factsheets, demonstrating the use of Emission modelling in the Management Cycle.

Based on a one-year surface water monitoring, samples were taken once a week and combined to two-months composite samples and analyzed. Sampling took place mostly at low and mean flow conditions. The monitoring was established in seven pilot regions in four countries (RO, BG, HU, AT) with a total of 20 surface water monitoring sites. From these results a mean annual concentration was calculated, which should be comparable to 12 fold monthly monitoring results, often used for the risk assessment under the Water Framework Directive. Monitoring results were supported by modelling results.

The risk assessment considers the following different inorganic and organic substances:

- Perfluorooctanesulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) (industrial chemicals),
- 16 EPA Polycyclic aromatic hydrocarbons (PAHs, industrial chemicals, and combustion by-products),

- Mercury (Hg), Cadmium (Cd), Copper (Cu), Nickel (Ni), Lead (Pb), Zinc (Zn), Chromium (Cr) and Arsenic (As) (Heavy metals) ,
- Diclofenac and Carbamazepine (pharmaceuticals),
- 4-tert-Octylphenol (industrial chemical),
- Nonylphenol (industrial chemical),
- Bisphenol A (industrial chemical),
- S-Metolachlor (herbicide) including Metolachlor-ESA and Metolachlor-OA (metabolites),
- Tebuconazole (fungicide).

Results from all monitoring stations and model results were compared with the environmental quality standards (EQS) of Directive2008/105/EU (Priority Substances) and with the substances enacted at the national level (National Substance List). Exceedances are shown in Table 1.

Table 1: Overview of the exceedance of the EQS in all pilot areas. The numbers indicate the number of sites, regions and countries with exceedance of the EQS values.

Substance > EQS	**Substance Group**	**No of monitoring sites**	**No of pilot regions**	**No of countries**	**Regulation**
PFOS	Industry	9	5	4	Directive 2008/105/EU
Cu	Heavy Metals	2	1	1	National Substance List
Cd	Heavy Metals	2	1	1	Directive 2008/105/EU
Zn	Heavy Metals	2	1	1	National Substance List
s-Metolachlor	Pesticides	2	1	1	National Substance List

In a second step, for each substance the dominant pathways were evaluated for each catchment by means of emission modelling. Considering the dominant polluters or emission pathways, scenarios were formulated, which describe the general potential of a specific measure to mitigate pollution.

The emission modelling was carried out for 34 sub-catchments in seven pilot areas. A detailed description of the model, the modelling results and validation can be found in OT 2.2 Report on improved system understanding. A SQLite model version with all seven pilot regions implemented and a technical description of the model setup can be found in OT 2.1 Harmonized MoRE Model (https://www.interreg-danube.eu/approved-projects/danube-hazard-m3c/outputs).

Note: The new proposals of the revised Priority Substance List were also assessed, but do not form a legal basis for the designation of measures at the present time.

2. General information Wulka pilot region

The pilot region Wulka located in Austria in the Pannonian plain west of Lake Neusiedl is divided into five sub-catchments (Figure 1). The sub catchment 12000 is not included in the emission modelling. Monitoring stations are situated in 12000 but are related to the outlet of 12001 and also the monitoring station providing information for the tributaries Eisbach is in sub catchment 12001 but is related to 12002. In the tributary Nodbach the third monitoring station was installed (12003).

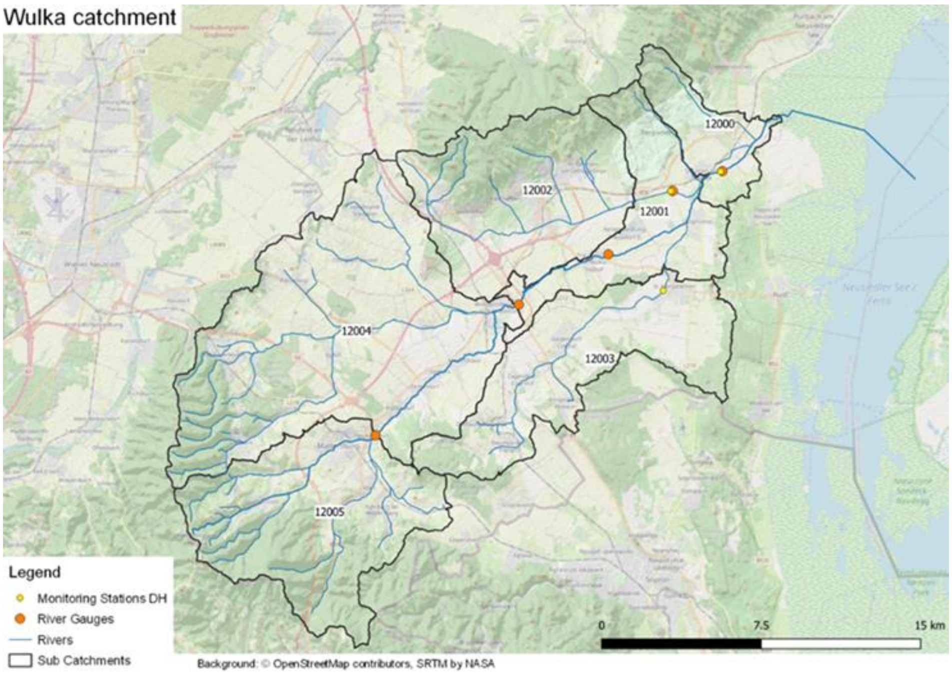

Figure 1: Overview of the pilot area, with monitoring stations.

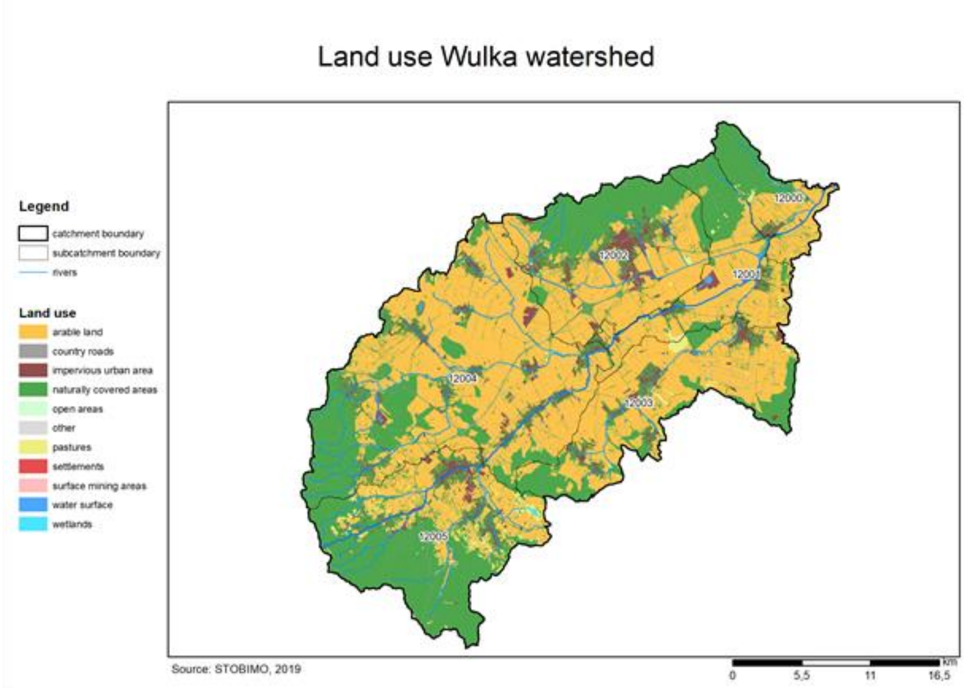

Figure 1: Land use in the pilot area.

The pilot region is dominated by arable land. Forests have higher shares in the upstream catchment (12005) and in 12004 as well as in the tributary Eisbach (12002). Here also the largest urban area in the pilot region, the capital of the province Burgenland "Eisenstadt" with around 15,000 inhabitants is located.

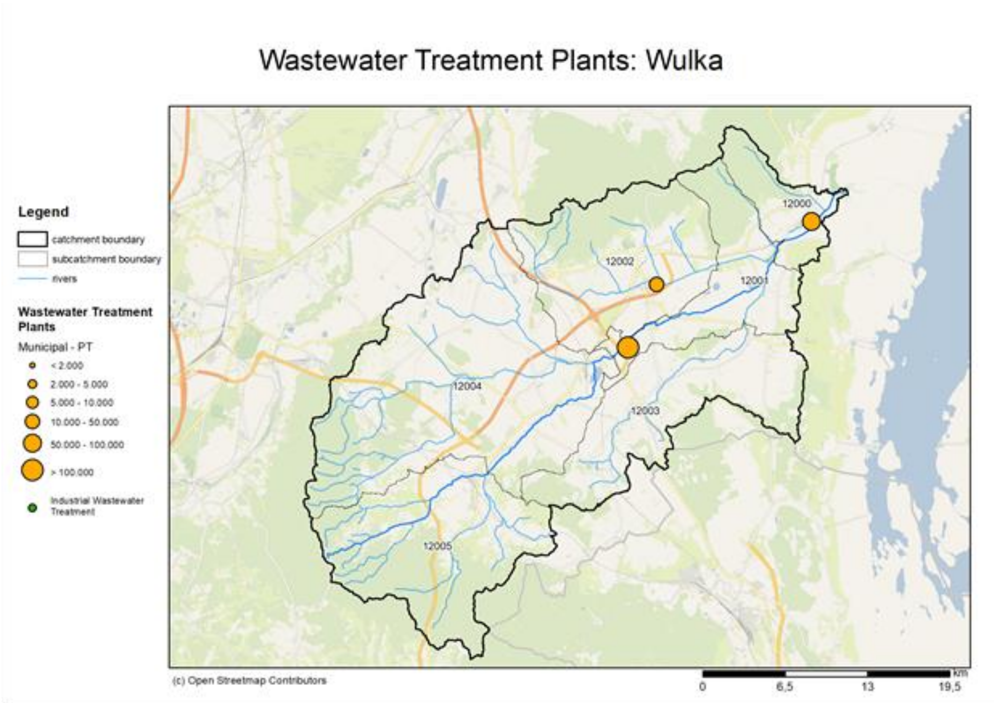

Figure 2: Overview of the point sources in the pilot area.

In the Wulka pilot region, the treatment plants under investigation have a capacity of 54,000 PE (12002) and 110,000 PE (12001) and are equipped with nutrient removal (N and P). The third treatment plant located in 12000 was not investigated in this project (Figure 3).

The population density in the pilot region Wulka is moderate, but compared to the other pilots in the upper third. The runoff is low and comparable to the low specific runoff of the pilot regions in Hungary.

Table 2: Basic information for the Wulka pilot region.

Pilot region	Catchment Area [km2]	Mean Elevation [m]	Population density [Inh/km2]	Arable land [%]	Arable land > 4% slope [%]	Pasture [%]	Forest [%]	Urban Area [%]	Runoff [mm]
Wulka	383	259,6	163	50,9	21,2	1,9	38,3	3,3	66

The water balance in this pilot is much more dominated by anthropogenic influences than any other pilot region under investigation in the project (Figure 4). The highest shares on runoff stem from the wastewater treatment plants (42%), while further 14% stem from the storm water, especially from combined sewer overflows. Only 26% stem from subsurface runoff (interflow and baseflow) with an additional high share of 9% from tile drainages.

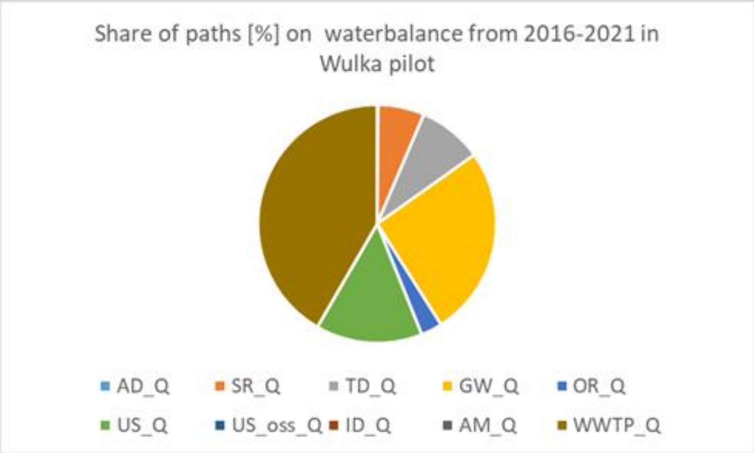

Figure 4: Share of different water balance components on the total runoff in the pilot region Wulka. (AD_Q: atmos-pheric deposition; SR_Q: surface runoff; TD_Q: Drainages; GW_Q: subsurface flow (base flow inter-flow); OR_Q: extra-urban roads; US_Q: combined storm water overflow and storm system; US_oss_Q: ID_Q: indus-trial WWTPs; sewer systems without connection to WWTP; AM_Q: abandoned mining; WWTP_Q: mu-nicipal WWTPs).

3. Risk assessment: Industry and wastewater/Perfluorooctane sulfonic acid (PFOS)

In the Wulka pilot region the PFOS EQS (0,00065 µg/l) is exceeded at all monitoring sites by factor 5,4 (12003), 6,2 (12002) and 6,1 (12001). Model results demonstrate, that even in the upstream sub catchments (12005 and 12004) there might be an exceedance of the PFOS EQS (factor ~2).

General information: Perfluorooctane sulfonic acid (PFOS) (CAS number 1763-23-1) belongs to the substance group of per- and polyfluorinated alkyl compounds. Due to the surface-active properties of PFOS and related compounds, they are also referred to as perfluorinated surfactants (PFTs). PFOS were formerly used in a wide variety of applications such as fire extinguishing foams, photo resist paints, photographic coatings, medical devices, insecticides, textiles and carpets, and paper and packaging. Due to persistence and surface-active properties, once contaminants such as PFOS enter wastewater, they are very difficult to remove. The main pathways of PFOS to enter in surface waters are wastewater effluents (industrial and municipal wastewater), surface runoff and groundwater.

3.1 A regionalized analyses of pathways in Wulka pilot region

In general, modelled area-specific loads are elevated in the Wulka pilot region (Figure 5). The area-specific loads in the sub-catchments underline the impact of the WWTPs located in 12002 and 12001. Here, the highest area specific loads are modelled. In 12003 the model results slightly under-estimate the loads. Nevertheless, even here slightly increased area-specific loads are modelled. In 12004 and 12005 even slightly higher area-specific loads are calculated by model results.

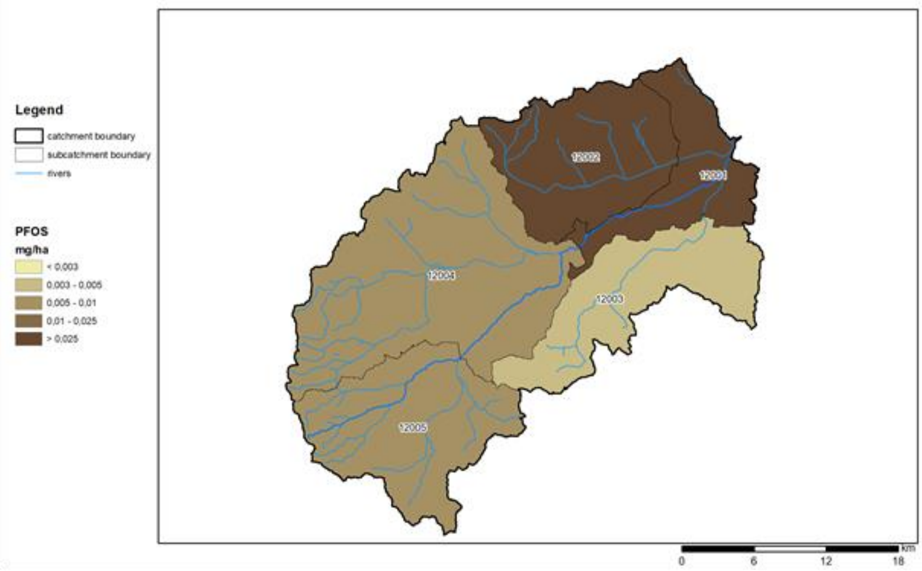

Figure 5: Area specific total PFOS emissions [mg/ha a] in the Wulka pilot region.

In the Wulka pilot region the WWTPs represent the dominant pathway with more than 60% (12002) and more than 80% in 12001. In catchment 12003 and the other two upper catchments high shares of PFOS emission stem from combined sewer overflows with 60% in 12003 and more than 40% of the total emission in 12004 and 12005. Comparable to results from other pilot regions, the share of emission form extra-urban roads seems to be overestimated in 12003, 12004 and 12005.

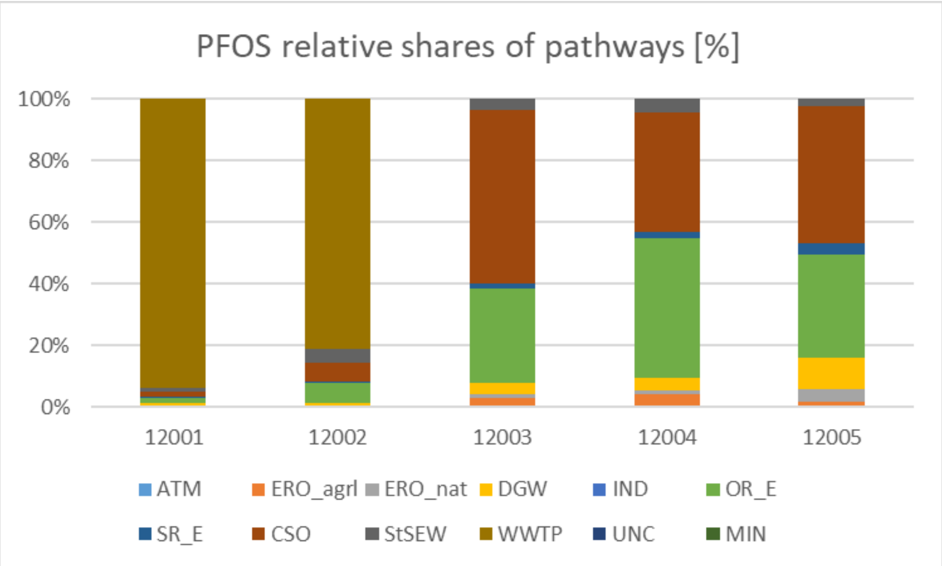

Figure 6: Relative share of pathways for PFOS in Wulka sub catchments. (ATM: atmospheric deposition; ERO_agrl: erosion from agricultural land; ERO_nat: erosion from forests; DGW: groundwater baseflow+inter-flow+drainages; IND: industrial point sources; OR_E: extra-urban roads; SR_E: surface runoff; CSO: combined stormwater overflow; StSEW: strom sewer; WWTP: municipal WWTP; UNC: sewer systems not connected to WWTP; MIN: abandoned mining).

3.2 Proposals for potential mitigation measures

For catchments, 12002 and 12001 the focus on possible mitigation measures to reduce PFOS emissions can be laid on the reduction of emission from wastewater treatment plants. Information from the Swedish EPA (2017) point out, that the purification capacity of PFOS can be increased to 75% by using activated carbon. The expansion of the large wastewater treatment plant of Wulkatal with an advanced purification stage is in line with actual proposals from the revised UWWTD presented for discussion with the member states. Here, a fourth treatment stage on municipal wastewater treatment plants >100,000 PE to be implemented by 2035 is proposed. For municipal WWTPs >10,000 – 100,000 PE in catchments with risk, the fourth treatment stage is proposed to be implemented by 2040.

In a previous study, scenarios were conducted for the Wulka catchment. (STOBIMO Spurenstoffe, https://info.bml.gv.at/themen/wasser/wasserqualitaet/fluesse_seen/stobimo-spurenstoffe.html)

Increasing the solids retention before discharge in storm water overflow and combined sewer overflow, point out only a slight reduction for PFOS. However, a higher share of storm water retained in the systems and transferred to the purification at the wastewater treatment plant would be a promising additional measure to reduce PFOS in sub catchments 12003, 12004 and 12005. Again, the proposed measure is based on proposals from the revised UWWTD, which discusses integrated management plans for municipal wastewater for settlement areas >100,000 PE as well as possible integrated management plans for municipal wastewater for settlement areas >10,000 – 100,000 PE in case of a risk.

As a consequence two kind of measures are proposed to reduce PFOS concentration in the sub catchments of the Wulka pilot region:

- Advanced wastewater treatment at treatment plant "Wulkatal" (100,000 PE) and "Eisenstadt" (54,000 PE). Adsorption stage (activated carbon) for municipal wastewater treatment plants.
- Increased retention capacity of combined sewer overflow and treatment on the plant "Wulkatal".

The advanced wastewater treatment was implemented as scenario in the MoRE model and its effectiveness quantified.

3.3 Presentation of the effectiveness of measures through scenario analyses

In the emission model the measure advanced wastewater treatment at the municipal wastewater treatment plants (>10,000 PE) was implemented.

If the PFOS concentration of municipal WWTPs with a capacity above 10,000 PE is reduced by 75%, due to the implementation of advanced treatment with activated carbon, the river concentration of PFOS will decrease by 66% in sub catchment 12002 and 63% in sub catchment 12002 (Table 3). Although, these reductions are significant, it would not be sufficient to fall below the EQS. However, a reduction of the exceedance of the EQS from factor 6 to factor 2 points out, that an improvement of the WWTPs will be a minimum requirement to undershoot the PFOS EQS. If these measures will be further supplemented by improved management of combined sewer overflows and of storm water overflows in the upstream catchments and in 12002 (Chapter 3.2), a PFOS EQS shortfall would be within reach.

Table 3: Reduction of PFOS river concentration in percentage.

ID of analytical unit	Reduction of river concentrations in %
12001	63
12002	66
12003	0
12004	0
12005	0

4. Literature

Swedish EPA (2017). Advanced wastewater treatment for separation and removal of pharmaceutical residues and other hazardous substances: Needs, technologies and impacts. Swedish Environmental Protection Agency. Report 6803, April 2017, Stockholm, Schweden. https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6803-5.pdf?pid=21820

European Commission, Impact assessment accompanying the proposal for a revised Urban Wastewater Treatment Directive, https://environment.ec.europa.eu/publications/proposal-revised-urban-wastewater-treatment-directive_en

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STOBIMO Spurenstoffe, 2019. https://info.bml.gv.at/themen/wasser/wasserqualitaet/fluesse_seen/stobimo-spurenstoffe.html